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## Effect of Diet on Aerobic Performance

Maureen Hall Fennerty

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EFFECT OF DIET  
ON  
AEROBIC PERFORMANCE

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A Thesis  
Presented to the  
School of Health, Physical  
Education, and Recreation  
and the  
Faculty of the Graduate College  
University of Nebraska

In Partial Fulfillment  
of the Requirements for the Degree  
Master of Arts  
University of Nebraska at Omaha

by  
Maureen Hall Fennerty  
December, 1979

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## THESIS ACCEPTANCE

Accepted for the faculty of the Graduate College,  
University of Nebraska, in partial fulfillment of the  
requirements for the degree Master of Arts, University of  
Nebraska at Omaha.

## Thesis Committee

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## Chapter 1

### THE PROBLEM

#### Introduction

Aerobic performance is affected by a number of physiological, psychological, sociological and environmental factors (Astrand, 1977). Among the many physiological factors nutrition plays an important part. However, when considering what constitutes a balanced diet, nutritionists express varying opinions as to what percentage of protein, fat and carbohydrate should be included for the general populace and the athlete. Mayer and Bullen (1960) in their review of literature on nutrition and athletic performance concluded a balanced diet is adequate for the athlete.

Protein is not used as a major energy source and therefore has no significant effect on athletic performance (Consolazio et al., 1975). Also, high protein diets usually contain a large quantity of fat (Smith, 1976). A high fat-protein diet given for 48 hours to eight highly trained runners produced a significant drop in performance during a ten mile run (Sienna et al., 1979). Bergstrom et al. (1967) placed subjects for three days on a high fat-protein diet or a high carbohydrate diet. Muscle biopsies taken during each diet regimen revealed a higher muscle glycogen content on the high carbohydrate diets. For long distance performance high carbohydrate diets have permitted subjects to maintain a faster pace throughout a race than when on a diet lower in carbohydrate content (Karlsson and Saltin, 1971). A high carbohydrate diet used for

two days after exercising until exhaustion increased muscle glycogen content to twice the pre-exercise levels (Bergstrom and Hultman, 1966).

### Significance of the Study

Nutritional status has been indicated to play an important role in long term endurance exercise (Astrand, 1977). The implications of research on this topic may apply to recreational and competitive athletes and their coaches as well as people engaged in manual labor. In particular those individuals participating in events where glycogen depletion is a factor may benefit. Extensive research has investigated the relationship of diet and long term work to exhaustion but few studies have examined the effects of an all-out 30 minute run in human subjects. This study will attempt to provide information regarding the role of diet in short but intense aerobic work.

### Statement of the Problem

The purpose of this investigation will be to examine the effect of diet on aerobic performance in adult male runners. On their assigned diets the subjects will be tested twice for the maximal distance covered while running 30 minutes on two non-consecutive days.

### Hypotheses

1. The group using the normal diet will run a shorter distance on the day of the first run than the group using a high carbohydrate diet.
2. The group using the normal diet will run a shorter distance on the day of the second run than the group using a high carbohydrate diet.

### Assumptions

The following are assumptions upon which this investigation is based:

1. Aerobic performance is affected by a number of physiological, psychological, sociological and environmental factors (Astrand, 1977).
2. Among the many physiological factors affecting performance nutrition plays an important part.
3. An all-out 30 minute run is predominantly dependent on aerobic metabolism.

### Delimitations

The participants in this study were ten male adult volunteers ranging in age from 17 to 32. Criteria for being a subject included the following:

1. Signing an informed consent statement.
2. Signing a contract of expectations.
3. Maintaining a written log of daily food intake and physical activity.
4. Being an experienced runner averaging a minimum of 30 minutes of running five days per week for the six months prior to the collection of data.

### Limitation

Participants were assigned a prescribed diet regimen which they prepared and ate at home and not in a controlled setting.

### Definitions

Normal diet. The normal diet consists of 48 percent of the calories from carbohydrate, 12 percent from protein and 40 percent from fat (United States Department of Agriculture, 1976).

High carbohydrate diet. The high carbohydrate diet consists of 75 percent of the calories from carbohydrate, 12 percent from protein and 13 percent from fat.

## Chapter 2

### REVIEW OF RELATED LITERATURE

The amount of research relating to the effect of diet on athletic performance is voluminous but centers around the question of what fuels are the major sources for muscular energy. The review of literature will analyze the effects of diets high in protein, fat, carbohydrate as well as the effects of a mixed diet on athletic performance.

#### Effects of a Mixed Diet

In reviewing the literature several authorities have supported use of the normal mixed diet for athletes. Upjohn et al. (1953) and Van Itallie et al. (1956) believe staying at an optimal weight plus eating a variety of foods will benefit athletic performance. Mayer and Bullen (1960) decided that the results of investigations on diets high in either protein, fat or carbohydrate do not discount the importance of a balanced diet. They also concluded there are no essential differences between the athletic and non-athletic diets.

#### Effects of a High Protein Diet

There is a general consensus that protein plays a minimal part as a source of fuel for muscular activity. Cathcart and Burnett (1925) had a subject perform on the hand-lever ergometer an hour each day for six days. The amount of nitrogen excreted after exercise was measured to determine protein utilization. From this they concluded protein has little energy value for working muscles, although it is an essential structural component of muscle tissue.

Robinson and Harmon (1941) investigated the effect of gelatin on non-athletic subjects training for a 26 week period. The nine participants were tested on a ten minute run, fifteen minute walk and timed races. Group I ingested the gelatin at the beginning of the 26 week training period and group II at the end of the period. From the results the investigators concluded that any increase in performance was due to training and not the gelatin supplement.

Darling et al. (1944) assigned 24 volunteers to either a low protein, high protein or control group during a two month period. While on the diet regimen subjects were frequently given a "pack test" which consisted of stepping up a 16 inch platform with the aid of handrails while wearing a knapsack weighing approximately one-third their body weight. The five minute pack test was given twice on each occasion with a 15 minute interval between tests. At the end of the investigative period no significant increase or decrease in performance was seen on either diet regimen.

Maison (1950) had four subjects work on a finger extensor ergograph until exhaustion for 31 consecutive days. Exhaustion was defined as a state when a constant work rate could not be maintained. The participants ingested a gelatin supplement for half of the investigative period. The results indicated performance was not enhanced on the gelatin supplement diet when compared to the non-gelatin diet.

A protein supplement and a placebo were used by Rasch et al. (1969) in a double blind study to determine the effect of protein on the performance of 32 men. The subjects participated in a physical fitness test which consisted of bent knee sit-ups, pull-ups, squat thrusts

and the standing broad jump. After four weeks of training the performance of all subjects on the fitness test increased significantly. However, there was no significant difference between the protein supplement group and the placebo group. The investigators attributed the increase in performance to training.

Consolazio et al. (1975) placed four male subjects on a high protein diet and four men on a normal protein diet. For 40 days the subjects participated in a vigorous physical activity program which included isometric exercises, calisthenics, treadmill walking, riding the bicycle ergometer and other activities. At the end of the study there was a significant increase in muscle mass and body protein stores in the high protein group. However, the supplemental protein did not enhance their performance.

Steben and Boudreaux (1978) randomly placed 18 male cross-country runners into one of three diet regimens for twelve weeks. Each subject ate a mixed diet plus either pollen extract, protein extract or a placebo. During this time they maintained their running schedule of 70 to 100 miles a week. A comparison of the results in a pre and post three mile run determining average velocity was significantly improved for all three groups. However, there were no significant differences in performance when comparing the three diet regimens.

#### Effects of a High Carbohydrate Diet

Cathcart and Burnett (1926) studied one subject on a fixed diet until nitrogen input equaled nitrogen output. This was followed by six days using the hand-level ergometer at moderate intensity for an hour

each day. An insignificant nitrogen output was seen at the time indicating protein plays a minimal role in supplying energy during athletic performance. The same subject ingested 360 grams of olive oil for three days, followed by three days of carbohydrates while doing the same ergometer task. The participant required slightly more oxygen on the high fat diet than the carbohydrate diet as measured by the respiratory quotient.

Marsh and Murlin (1928) tested one subject on the bicycle ergometer while on a mixed diet, high carbohydrate diet and a high fat diet. There was a 12 percent increase in efficiency on the high carbohydrate diet as compared to the mixed diet. There was also a nine percent decrease in the amount of work performed on the ergometer after four days on the high fat diet.

In Gemmill's (1942) review of literature he concluded that carbohydrate is the primary fuel for muscular activity. He based his conclusion on the following points: the drop in blood sugar during long endurance events indicating the utilization of carbohydrate during exercise, the increase in efficiency and endurance while on a carbohydrate diet and the production of lactate at the onset of exercise and during rigorous activity. Gemmill also noted that up to 1942 there were no investigations indicating muscles utilize fat during exercise. However, today it is known that fat is directly used by the muscles during physical activity (Hedman, 1957; Hultman and Bergstrom, 1967).

Bergstrom and Hultman (1966) took a needle biopsy from the quadriceps femoris muscle of four subjects after a twelve hour fast. The participants were then instructed to ride the bicycle ergometer for



30 minutes. Immediately following the ride a second biopsy was taken; a third biopsy was also done one hour after the bicycling ended. An examination of the extracted tissue indicated that during physical activity muscle glycogen is the main carbohydrate source.

Bergstrom et al. (1967) instructed nine male physical education students to ride a bicycle ergometer until exhaustion. Three of the subjects were then placed on a high carbohydrate diet for three days and the remaining six participants were placed on a high fat-protein diet for the same amount of time. After the third day the nine subjects rode the bicycle ergometer at a 75 percent work load until exhaustion. Following the bicycling the subjects switched diet regimens so each subject experienced both diets. After another three days the participants performed the same work loads. Leg muscle biopsies taken during each diet regimen revealed a higher muscle glycogen content during the high carbohydrate diet for all subjects. There was a significant correlation ( $p < .05$ ) between the time on the bicycle ergometer and the muscle glycogen content. The average performance time on the high fat-protein, mixed and high carbohydrate diet was 59, 126, and 189 minutes, respectively.

Hultman and Nilsson (1971) put seven subjects on a carbohydrate-free diet for ten days. Each day a liver biopsy was taken to determine glycogen content. At the end of this period the liver glycogen decreased significantly. After five days of carbohydrate feeding the liver glycogen significantly increased. The investigators then tested the effect of one hour of heavy exercise on liver glycogen and found that an insufficient amount of carbohydrate in the diet results in liver

glycogen utilization. However, during prolonged physical activity the liver glycogen stores may be insufficient in meeting the amount of glucose needed.

Karlsson and Saltin (1971) studied the effect of an uncontrolled mixed diet and a high carbohydrate diet on ten male subjects running approximately twenty miles. Some were cross-country runners while the others were only slightly trained. Two different but similar races gave each subject an opportunity to follow both diet regimens. A high carbohydrate diet and a special training program allowed the runners to maintain a constant pace throughout the race. The treatment consisted of one day of heavy exercise lasting a minimum of two hours one week before the race followed by three days of no carbohydrate intake while training. The next three days participants ate a minimum of 2,500 calories from carbohydrates per day with no training. After the special regimen the mean muscle glycogen content in the quadriceps was 35g/k wet muscle while on the mixed diet the mean was 17g/k wet muscle. Also the subjects on the mixed diet slowed their pace towards the end of the race.

Gollnick et al. (1972) observed four subjects on a high carbohydrate diet, high fat-protein diet and a mixed diet. Participants rode a bicycle ergometer at 74 percent of their aerobic capacity for thirty minutes after three days on each of the diets. A muscle biopsy of the quadriceps muscle revealed the mean glycogen content on the mixed, high fat-protein and high carbohydrate diets was 87, 43 and 144 mmol glucose/kg wet muscle, respectively.

Sienna et al. (1979) studied four male and four female highly trained runners in four running events. Test I was a treadmill test to

determine maximum aerobic capacity; test II was a ten mile competitive road race; test III was a ten mile treadmill run on their normal diet; test IV was the same as test III except subjects were on a high fat-protein diet for 48 hours. A comparison of the runners' performances after the two diets revealed a significant ( $p < .05$ ) drop in pace while on the high fat-protein diet beginning at approximately the fifth mile and continuing to the end of the race. The drop in pace also coincided with decreased glucose levels.

#### Effects of a High Carbohydrate Diet on Glycogen Depletion

In a series of four experiments Krogh and Lindhard (1920) placed two subjects on a high fat diet and two subjects on a high carbohydrate diet for three to six days. During this time the participants performed on the bicycle ergometer until exhaustion each day. After several days on a normal diet the subjects switched diet regimens and rode the bicycle ergometer for the same period of time. An 11 percent increase in performance was seen in both groups after the carbohydrate diet.

Dill et al. (1932) ran a dog for six and one half hours to exhaustion on the treadmill after a 36 hour fast. On a second run 18 days later the dog was given a high carbohydrate feeding one hour before the run and at 50 minute intervals. With the carbohydrate feeding the dog ran for 13 miles without showing signs of fatigue. The results indicated exhaustion in the six and one half hour run was due to glycogen depletion while the lack of fatigue in the 13 mile run was due to the carbohydrate feedings.

Hedman (1957) investigated the fuel sources and energy demands of cross-country skiing. Four male subjects were instructed to ski at

a constant rate until exhaustion after having fasted for twelve hours. Depletion of muscle glycogen resulted in a transition from carbohydrate-dominant to fat-dominant metabolism as shown by the respiratory quotient. A comparison of oxygen uptake before and after skiing emphasized the inefficiency of the fat-predominant metabolism. Significantly more oxygen was consumed once the muscles were glycogen depleted and dependent solely on fat for energy.

Bergstrom and Hultman (1966) placed two males on either side of a bicycle ergometer to pedal with one leg until exhaustion. The rest of the day and for the next two days the subjects ate a high carbohydrate diet. Muscle biopsies of the quadriceps femoris in the exercised leg revealed the muscle glycogen content was very low after exercise. However, after two days on the high carbohydrate diet the glycogen content of the exercised leg was significantly higher than in the resting leg.

Ahlborg et al. (1967) took muscle biopsies from the quadriceps muscles of the nine volunteers after they performed until exhaustion on the bicycle ergometer at a work load equal to 52 percent  $\dot{V}O_2$  max. A significant correlation was found between the initial glycogen content and performance time. There was also a significant correlation between the decrease in muscle glycogen and performance time. The results indicate a high glycogen muscle store is necessary for lengthy endurance performance.

Bergstrom and Hultman (1967) muscle biopsied the quadriceps muscles of eight males before and after work periods on the bicycle ergometer. A work period consisted of 15 minutes of riding followed by

15 minutes of resting. An analysis of the data revealed the greatest glycogen breakdown occurred during the first 15 minute work period. Once the glycogen levels were depleted the participants were unable to perform on the bicycle.

Hermansen et al. (1967) worked ten untrained and ten trained male subjects on the bicycle ergometer until exhaustion. As the work load increased from 29 to 78 percent of  $\dot{V}O_2$  max in an 80 minute period, there was a significant increase in carbohydrate combustion as shown by the respiratory quotient. Also, muscle biopsies taken before and after bicycling revealed a significant decrease in the glycogen content of the exercised muscles.

Hultman and Bergstrom (1967) using four subjects depleted the muscle glycogen by pedaling a bicycle ergometer with one leg. Depletion was determined by muscle biopsy. Half of the subjects were then placed on a high fat-protein diet for three days and the remaining two subjects were not allowed to eat for two days. On the starvation diet the mean increase of glycogen content in the exercised leg went from .065g to .37g/100g wet muscle. On the high fat-protein diet the mean increase of the glycogen content in the exercised leg rose from .075 to .42g/100g wet muscle. All subjects were then placed on a four day high carbohydrate diet after which another biopsy was done. Glycogen resynthesis after the carbohydrate diet for both groups showed a mean increase of .24g to 6.25g/100g wet muscle. An analysis of the data revealed the high fat-protein diet and the starvation diet increased muscle glycogen levels at a very slow rate, whereas glycogen resynthesis on the high carbohydrate diet was extremely rapid and rose above the level of the resting leg.

The effects of a high fat, high carbohydrate and a mixed diet regimen was studied by Pruett (1970) with nine men as subjects. Each participant rode a bicycle ergometer until exhaustion after fourteen days on a specific diet regimen. While pedaling at 70 percent  $\dot{V}O_2$  max the subjects rode for 164, 187 and 193 minutes on the high fat, mixed and high carbohydrate diets, respectively.

Brooke et al. (1975) had eight trained bicyclists ride at 67 percent of their  $\dot{V}O_2$  max until exhaustion. The subjects were randomly assigned to one of four diet treatment groups: I. 250 ml. glucose syrup with added sugars; II. canned rice pudding; III. a low calorie fluid with added salts; IV. no food. The diet treatments were presented every twenty minutes while riding. The glucose syrup and rice pudding produced significantly longer riding times ( $p < .05$ ) than either the low calorie fluid or no food intake.

In an investigation by Carlson and Zuti (1977) five male runners ran on a treadmill at 75 percent of their  $\dot{V}O_2$  max 45 minutes a day for six consecutive days. The participants were on the following dietary schedule: normal diet on day one; no carbohydrates for days two, three and four; and a normal diet on days five and six. A comparison of the data revealed the inefficient use of fat for energy during the carbohydrate restricted diet.

### Summary

Research on the effects of diet on aerobic performance has focused on the effect of protein, fat, carbohydrate and a mixed diet. It is apparent that carbohydrate and fat are the major sources for muscular fuel whereas protein plays a minimal role. In many studies,

however, carbohydrate has shown to be more efficient than fat during physical activity. Research including balanced or mixed diets is difficult to evaluate because these terms were often not specifically described.

Investigations on different diet regimens have largely employed highly impractical diets such as high carbohydrate and high fat diets. No studies were found analyzing the effect of the typical American diet on performance which consists of 40 percent fat, 12 percent protein and 48 percent carbohydrate (United States Department of Agriculture, 1976). Also, there were few studies where participants did not exercise until exhaustion.

## Chapter 3

### PROCEDURES

#### Subjects

The subjects in this study were 10 male adult volunteers.

Criteria for being a subject included:

1. Signing an informed consent statement.
2. Signing a contract of expectations.
3. Maintaining a written log of daily food intake and physical activity.
4. Being an experienced runner averaging a minimum of 30 minutes of running five days per week for the six months prior to the collection of data.
5. Being no more than 35 years of age and in good health.

Characteristics of subjects are indicated in Table 1.

TABLE 1 - Data on the 10 Subjects.

Subjects	Age (yrs.)	Height (cm.)	Weight (kg.)
Da. B.	25	166	63.0
Ja. B.	22	175	66.5
Jo. B.	17	170	80.5
Du. B.	32	174	66.5
L. H.	26	186	72.5
J. J.	20	180	60.5
J. L.	23	177	69.5
D. P.	27	176	71.0
P. P.	24	189	80.0
W. S.	25	186	86.0



### Description of Treatment

Five days before the beginning of the treatment period a pre-test was conducted to determine the maximal distance run in 30 minutes around the University of Nebraska at Omaha indoor track. From the results of the pre-test the participants were blocked into one of two diet regimens. However, due to the dropping out of four subjects on the high carbohydrate diet the blocking did not equalize the groups in terms of running ability.

On the day of the pre-test each subject handed in a written three day diet survey to the investigator. From the survey the average caloric intake for each participant was determined using tables from the United States Department of Agriculture Bulletin, Number 92 (United States Department of Agriculture, 1971). During the treatment period subjects consumed the same number of calories as reported on their three day diet survey. However, the percentage of protein, fat and carbohydrate was manipulated depending on the diet in which the participant had been blocked. Table 2 summarized the diet regimens.

TABLE 2 - Diet Regimens.

	Diet I	Diet II
Carbohydrate	48%	75%
Protein	12%	12%
Fat	40%	13%

Diet I represents the typical American diet (United States Department of Agriculture, 1976) while diet II is a high carbohydrate

diet. Subjects prepared and ate their meals at home while on the prescribed five day diet. They were required to carefully measure all food portions. Each diet was individualized and provided a variety of foods from which to select. No vitamin or mineral supplements were taken during the investigations.

Subjects adhered to the assigned diet for five days beginning on a Monday and ending on a Friday. On day three and day five they were tested on the maximum distance covered in thirty minutes of running which is similar to a competitive athlete's schedule of two races a week. On days one and two subjects were not permitted to do any speedwork or run longer than 30 minutes. On day four subjects were told not to engage in any activities which would involve considerable energy expenditure such as walking and bicycling for more than ten minutes. Table 3 summarizes the experimental design.

TABLE 3 - Experimental Design.

Day	1	2	3	4	5
	No speedwork or 30 minute run		30 minute run	no major physical activity	30 minute run

#### Measurement Procedures

Before each run subjects jogged a quarter of a mile for a warmup. This was followed by an all-out run to determine the maximum distance covered in 30 minutes. Times were called out to each runner and recorded every one-quarter mile. Subjects were then requested to jog at least a

quarter of a mile for cooldown.

The running was timed with stopwatches on the University of Nebraska at Omaha indoor track. The track is unbanked, consists of a rubberized surface, and is one-eighth of a mile long. Subjects were told not to consume food, coffee, tea or any beverages other than water for two and one-half hours prior to testing.

### Statistical Treatment

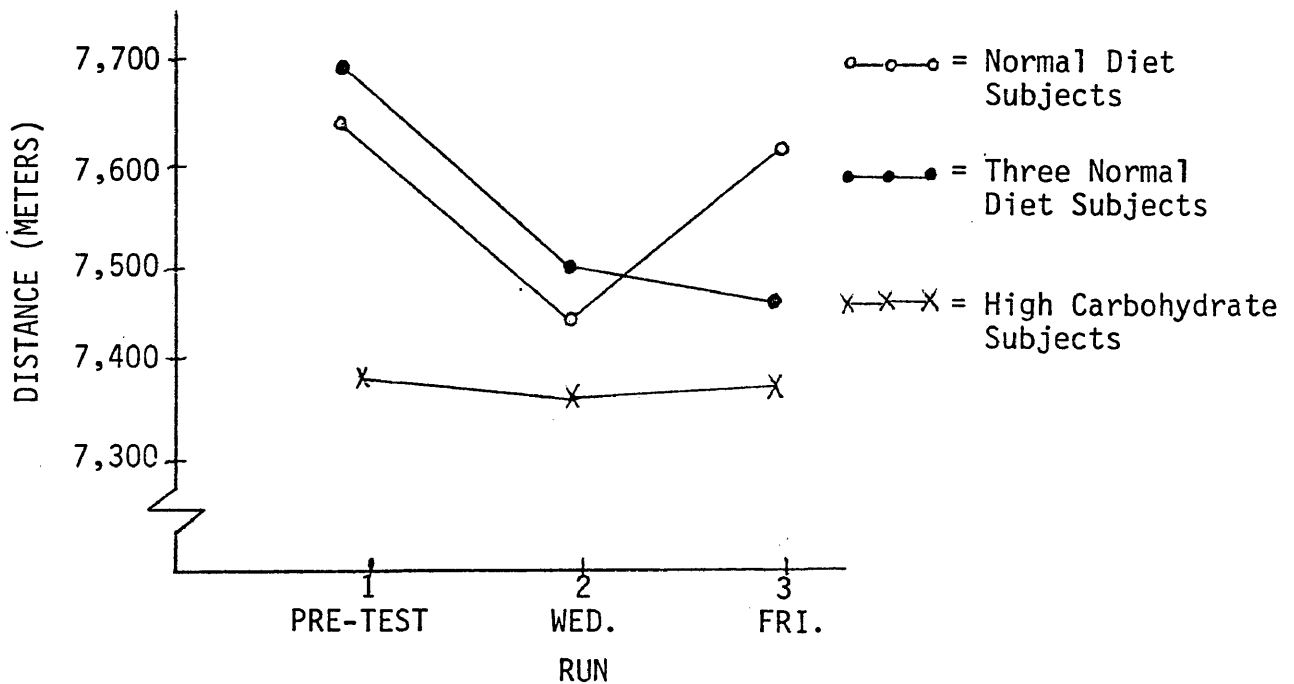
The mean, standard deviation, range and correlation were used to describe and compare the running scores of the subjects on the two diet regimens. Due to the dropping out of four subjects an analysis of covariance (ANCOVA) was used to compare the effects of a normal and high carbohydrate diet on the maximal distance run in 30 minutes. The .05 level of significance was used for the correlation and analysis of covariance tests. Data was analyzed at the University of Nebraska at Omaha computer facility.

## Chapter 4

### RESULTS

A summary of the results is provided in Figure 1. As shown in the figure and Table 4 the mean distance run by the seven subjects on the normal diet did drop slightly but progressively from the first to the third running test. The pacing pattern of the three subjects on the normal diet matched in running ability with the subjects on the high carbohydrate diet is shown in Figure 1.

FIGURE 1 - Mean Distance Run



As can be seen in Figure 1 and Table 5 the mean running scores of the three subjects on the high carbohydrate diet dropped slightly from the pre-test to the run after three days on the diet. A comparison

TABLE 4 - Descriptive Data for the Normal Diet Group (Meters).

	<u>M</u>	<u>S.D.</u>	RANGE
PRE-TEST	7684.6	747.77	6737.7 - 8899.8
WED.	7434.4	969.11	5882.9 - 8598.1
FRI.	7420.1	1038.95	5631.5 - 8799.2
ALL 3 DAYS	7513.1	918.61	5631.5 - 8899.8

of the mean running scores after three and five days on the high carbohydrate diet revealed a slight increase in performance. Across both groups the run on Friday was inferior to the pre-test performance.

TABLE 5 - Descriptive Data for the High Carbohydrate Diet Group (Meters).

	<u>M</u>	<u>S.D.</u>	RANGE
PRE-TEST	7374.6	1473.07	6285.2 - 9050.6
WED.	7340.4	1341.05	6285.2 - 8849.5
FRI.	7352.9	1385.72	6242.9 - 8899.8
ALL 3 DAYS	7352.9	1399.94	6242.9 - 9050.9

Significant correlations may be found among the three running performances of the normal diet subjects as shown in Table 6 and among the three running performances of the high carbohydrate subjects as shown in Table 7. The highly significant relationships indicate a great deal of consistency among the mean running scores on the three days.

The correlations among the running performances of the high carbohydrate group are generally higher and more constant.

TABLE 6 - Pearson Correlation Coefficient for the  
Three Running Performances of the  
Normal Diet Subjects.

	$X_1$ PRE-TEST	$X_2$ WED.	$X_3$ FRI.
$X_1$	-	.8412 <sup>a</sup>	.8241 <sup>a</sup>
$X_2$	-	-	.9791 <sup>b</sup>
$X_3$	-	-	-

a .05 level of significance

b .01 level of significance

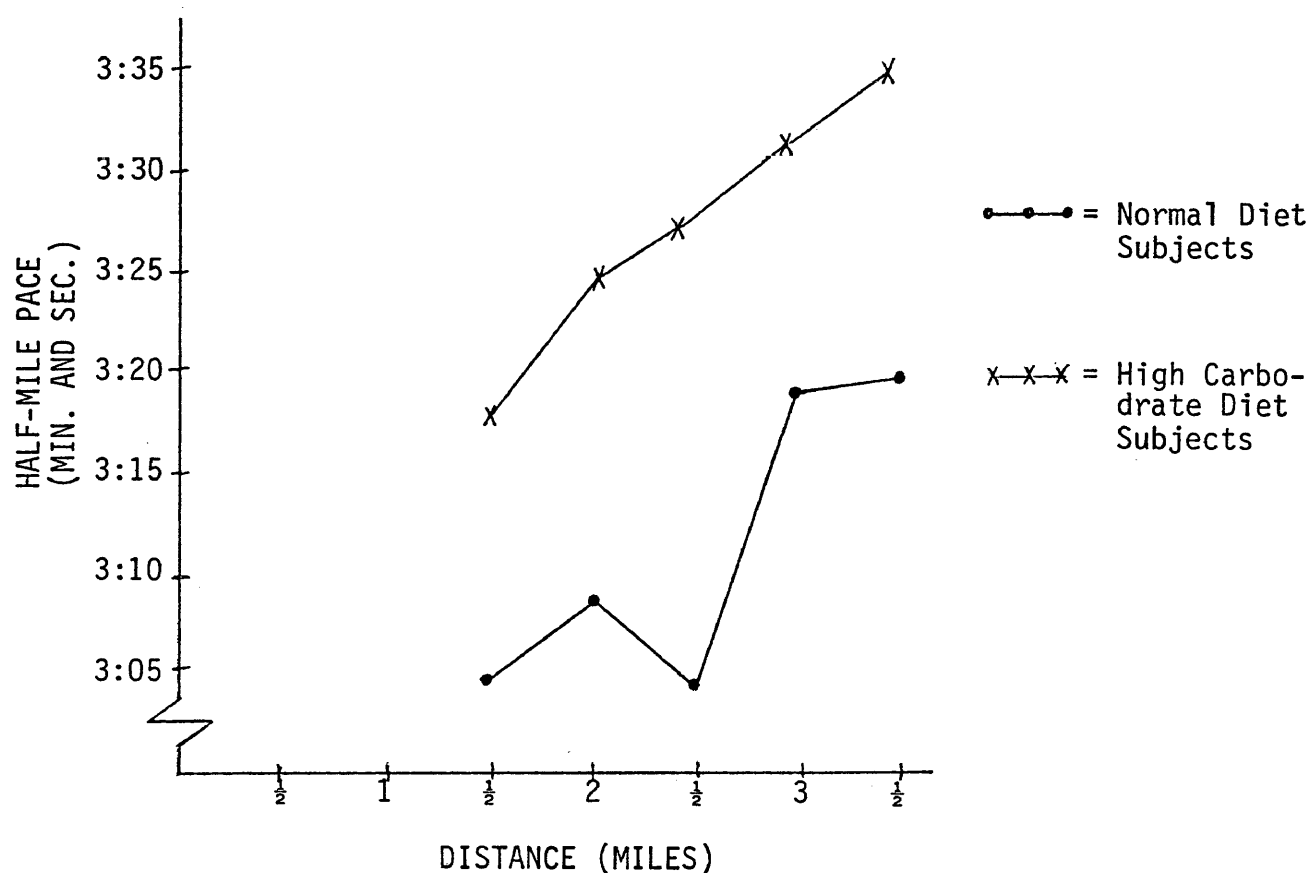
TABLE 7 - Pearson Correlation Coefficient for the  
Three Running Performances of the High  
Carbohydrate Diet Subjects.

	$X_1$ PRE-TEST	$X_2$ WED.	$X_3$ FRI.
$X_1$	-	.9985 <sup>a</sup>	.9980 <sup>a</sup>
$X_2$	-	-	1.0000 <sup>a</sup>
$X_3$	-	-	-

a .01 level of significance

As can be seen in Figure 2 the subjects on the normal diet ran a faster pace than the subjects on the high carbohydrate diet during the

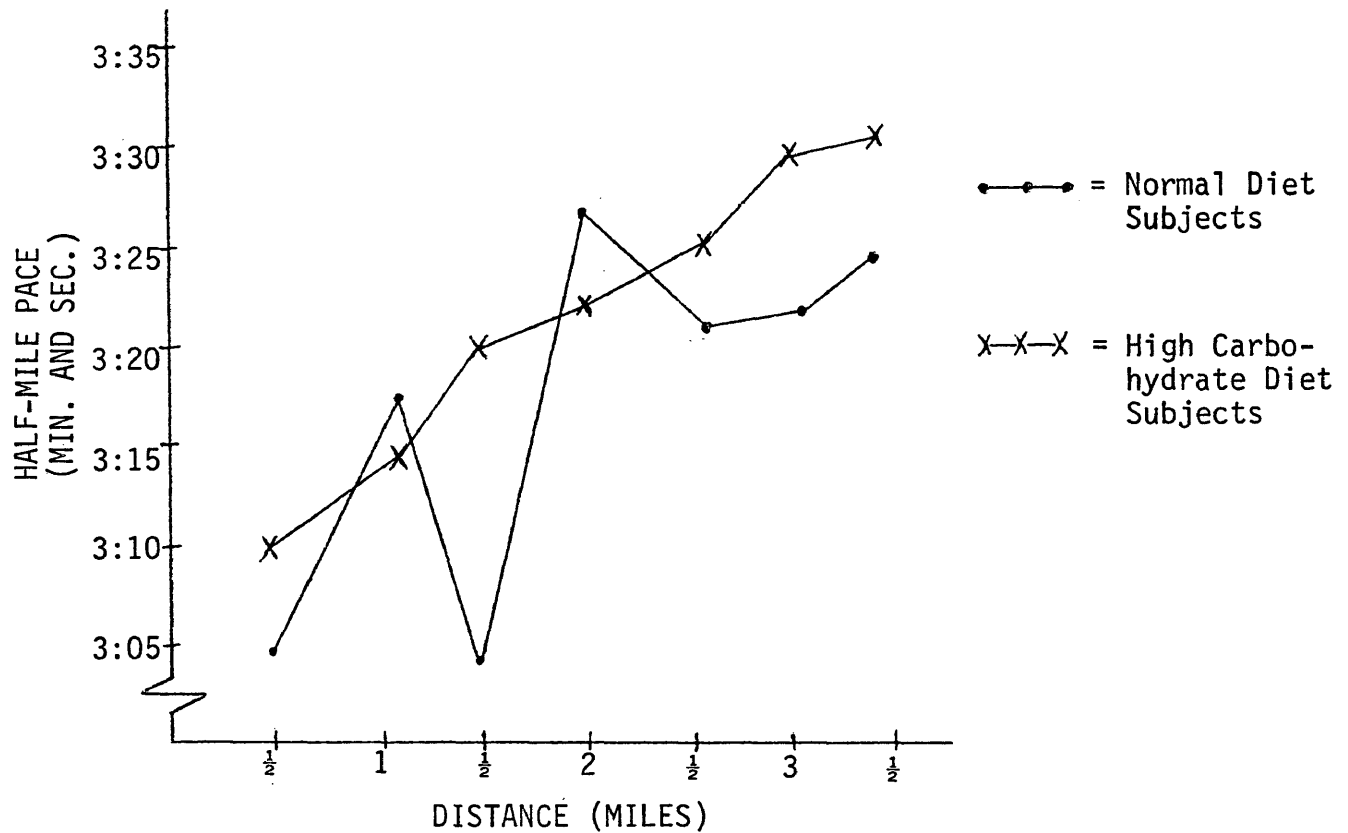
FIGURE 2 - Pre-test Pacing Pattern



pre-test. The pacing pattern for the race on Wednesday had similar results to the pre-test as shown in Figure 3. However, on Wednesday both groups ran at a slower pace than on Thursday. This may have been due to the higher temperature in the field house on Wednesday.

On the third run the pace of the subjects in the high carbohydrate group was faster compared to the pace of the subjects on the

FIGURE 3 - Wednesday's Pacing Pattern

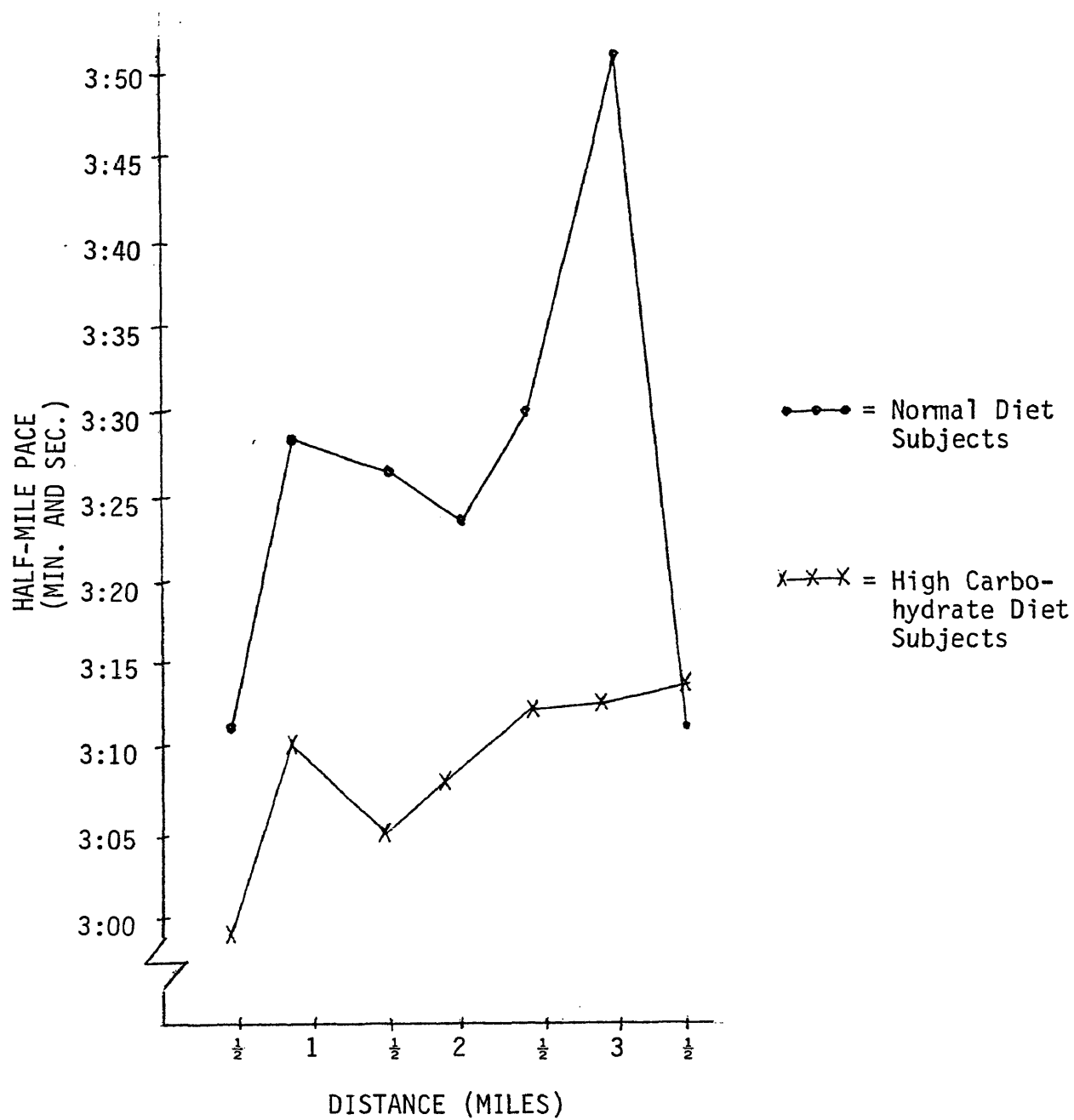


normal diet as shown in Figure 4. The carbohydrate group also ran a faster pace on the third run compared to their second run while the subjects on the normal diet ran a slower pace on Friday compared to the run on Wednesday. On the second and third run it appears that the pace was more even for the carbohydrate group than for the group using a normal diet. Although no significant differences were found between or within groups significant results may have been found with a larger number of subjects.

No significant differences were found when an independent t-test was used to compare the pre-test scores of the subjects on the



FIGURE 4 - Friday's Pacing Pattern



normal diet and the high carbohydrate diet as shown in Table 8.

TABLE 8 - Comparison of Pre-test Scores  
Between the Normal Diet Group and  
High Carbohydrate Diet Group

	Subjects	<u>M</u>	<u>S.D.</u>	t-ratio	p
Normal Diet	7	7684.6	747.77	3.88	1.66
High Carbohydrate Diet	3	7374.6	1473.07		

The analysis of covariance shown in Table 9 revealed no significant differences occurred within or between groups when comparing the mean running performances after three and five days on either a normal diet or a high carbohydrate diet.

From the statistical analysis of the data the hypothesis that the subjects on the normal diet would run a shorter distance on Wednesday and Friday compared to the subjects on the high carbohydrate diet was not supported.

TABLE 9 - Analysis of Covariance

SOURCE	SS	df	MS	F RATIO	p<
Between Subject Factors					
Diet	211701.83413	1	211701.83413	.39435	.550
Covariate (Pre-test Run)	15647988.99069	1	15647988.99069	29.14834	.001
Error	3757878.64979	7	536839.80711		
Within Subject Factors					
Run 2+3	127.60060	1	127.60060	.00714	.935
Run (2+3) x Diet	328.60060	1	328.60060	.01838	.895
Error	142992.95190	8	17874.11899		

## Chapter 5

### DISCUSSION

It was hypothesized that the group using the normal diet would run a shorter distance than the group using the carbohydrate diet on days three and five of the prescribed diet. Failure to produce significant differences within each group as well as between groups may be partially attributed to the dropping out of four subjects in the high carbohydrate group. Consequently, only three subjects remained in the high carbohydrate group compared to seven in the normal diet group. The likelihood of achieving significance decreases with a smaller sample.

Karlsson and Saltin (1971) found significant differences in running performances between a high carbohydrate group and a mixed diet group. However, the investigators also depleted the subjects' leg muscle glycogen levels before placing them on a high carbohydrate diet. Bergstrom et al. (1967) found an increase in performance ( $p < .05$ ) with nine subjects on either a high carbohydrate diet or a high fat-protein diet when exercised until exhaustion on a bicycle ergometer.

Glycogen depletion is more likely in less fit subjects since highly trained individuals utilize free fatty acids as an energy source more effectively (Issekutz et al., 1965). The fastest runner in the investigation ran 8899.8 meters in 30 minutes while the slowest runner ran 5631.5 meters in the same period. Several of the subjects whose running performance was below the mean would seemingly have been more strongly affected on Friday's test as the glycogen content in their musculature would theoretically be lower. However, the data do not support

this contention. Hermansen et al. (1967) exercised trained and untrained subjects on the bicycle ergometer until exhaustion. After 20 minutes of exercise glycogen content was lower in the untrained group.

The 30 minute all-out run might not have been of adequate duration to produce any significant results. Glycogen depletion doesn't tend to appear in trained athletes until 90 minutes and 85 minutes in the untrained (Hermansen et al., 1967). Bergstrom and Hultman (1966) exercised their subjects for 30 minutes and found a significant ( $p < .05$ ) mean decrease in muscle glycogen of 29 percent. Gollnick et al. (1972) also exercised their participants for 30 minutes and found the mean glycogen concentrations in the quadriceps muscle were 87, 43 and 144 mmol glucose/kg wet muscle after subjects had been placed on a mixed, high fat-protein and high carbohydrate diet, respectively.

Another factor affecting the results was the inability of the investigator to feed the subjects in the laboratory. Therefore, ideal control of the participants' adherence to the diet regimens was not possible. With the small sample size the effect of a single subject failing to closely adhere to the diet may have had an appreciable effect on the group data.

Several other factors may have affected the results of the investigation. The participants were not accustomed to running indoors. The monotony of running around a track combined with the high temperature in the field house on Wednesday may have inhibited their effort. Also, one runner walked three laps in the pre-test because of stomach cramps; a high carbohydrate subject rode his bicycle to the field house for race three; and two subjects made significant deviations from their

prescribed diet. Perhaps a monetary award may have provided more of an incentive for the subjects to follow the investigation guidelines.

## Chapter 6

### SUMMARY, CONCLUSION AND RECOMMENDATIONS

#### Summary

The purpose of this investigation was to study the effect of diet on aerobic performance in adult male runners. Subjects used in the study were 10 adult male runners ranging in age from 17 to 32. Five days before the beginning of the treatment period a pre-test was conducted to determine the maximal distance run around the University of Nebraska at Omaha indoor track. Subjects were then blocked into either a normal diet or a high carbohydrate diet. Participants adhered to the assigned diet for five days beginning on a Monday and ending on a Friday. On day three and day five they were tested on the maximum distance covered in thirty minutes of running around the University of Nebraska at Omaha indoor track. The result was that no significant differences occurred within or between groups when comparing the mean running performances after three and five days on either a normal diet or a high carbohydrate diet.

#### Conclusion

The following conclusion is justified by the findings of this investigation: Diet manipulation did not significantly alter all-out running performances of 30 minute duration.

#### Recommendations

As a result of this investigation, the following recommendations are made:

1. Data be collected on a larger number of subjects.
2. Food, lodging and a monetary reward be provided for the subjects during the investigation to better control diet and activity.
3. A longer investigative period be used with more than two 30 minute all-out runs during that time.
4. The effect of diet on running performance in women be investigated to determine if the sexes respond differently.
5. Subjects of elite as well as average fitness levels be studied to determine if various fitness levels are affected differently by nutritional status.



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## APPENDICES

APPENDIX A  
INFORMED CONSENT FORM

THE UNIVERSITY OF NEBRASKA AT OMAHA  
INFORMED CONSENT FORM

You are invited to participate in a study aimed at studying the effect of diet on distance running. It is hoped to determine if the typical American diet and a high carbohydrate diet differ as to their effect on distance running. You were selected as a possible participant because you are a conditioned runner.

Participants in the study will run three, 30-minute races on the indoor track at UNO and will follow a prescribed diet, either the typical American diet or a high carbohydrate diet, for five days. It is estimated that the total time spent in racing and recording dietary information on a diet recall form will be four and one-half hours. Possible risks to you include pulled muscles, sore muscles and other aches and pains common to runners. If you decide to participate, Mrs. Maureen Fennerty will describe in detail the above procedures.

If physical injury occurs as a direct consequence of these procedures, the medical care required to treat the injury will be provided at no expense to you, providing that the cost of such medical care is not reimbursable through your own health insurance. However, no additional compensation for loss of income, pain and suffering or other form of compensation will be provided as a result of such injury and any subsequent medical care, including hospitalization.

All personal information (e.g., name, vital statistics) collected in this study will remain confidential. However, the data will be statistically treated and written up as a portion of the requirement for a Master's thesis. Your name will not be associated with data. In signing this document, you approve of the collected data being used in this manner.

Your decision whether or not to participate will not prejudice your future relations with the University of Nebraska at Omaha. You should feel free to withdraw from participation in the study at any time without prejudice.

If you have questions regarding any facet of the study, please ask. Mrs. Fennerty (phone 554-2670) will be happy to answer any additional questions that you may have at a later date.

You will be given a copy of this form to keep for your personal records.

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE HAVING READ THE ABOVE INFORMATION.

---

Date

---

Signature

---

Witness

---

Investigator

APPENDIX B  
THREE DAY DIETARY STUDY

### 3 Day Dietary Study

Mon., Tues. and Wed. (Oct. 8-10)

1. List all the food and drink you consume for 3 days. Be sure to list snacks including gum and lifesavers. List food brand names if possible.
2. Estimate all food and drink consumed to the nearest unit of measurement as indicated below:
  - a. foods measured with a measuring cup to the nearest  $\frac{1}{4}$  cup.
  - b. foods measured with a tablespoon,  $\frac{1}{2}$  tablespoon and  $\frac{1}{4}$  tablespoon.
  - c. foods measured with a teaspoon,  $\frac{1}{2}$  teaspoon and  $\frac{1}{4}$  teaspoon.
  - d. foods which may be measured in ounces or the number of servings.  
Examples include: 1 medium apple, 1 hot dog (8 per pound package),  
1 small egg, 1 cookie (brand name or if home-made the size of the cookie).
3. Be specific about the following food or drink characteristics:
  - a. the kind and brand of cheese.
  - b. the kind and brand of yogurt.
  - c. describe milk as being skim, 2% or whole.
  - d. describe meat as being lean, super lean or extra lean.
  - e. note when vegetables and fruit are fresh, frozen or canned.
  - f. note the kind of bread eaten (i.e., white or whole wheat), brand name and # of slices).
  - g. note whether mayonnaise or salad dressing is used.
  - h. note when the foods are low calorie (i.e., Kraft low-calorie French Dressing).
  - i. list condiments (mustard, ketchup, barbecue sauce, etc.).



- j. note how much salt, pepper, butter or margarine is used.
- k. note how the foods are cooked (when applicable).
- l. note any alcoholic beverages consumed, amount, type and brand name (i.e., gin, vodka, Miller beer, Miller lite beer).

BE VERY SPECIFIC AS TO AMOUNT, BRAND, HOW IT IS COOKED (when applicable) AND WHEN EATEN.

If there are any questions please call Maureen Fennerty at 393-3326. This diet survey will be used by the investigator to figure out your approximate daily caloric intake. It will also be used when making up the assigned diet menu for the week of October 15-19.

A sample one day diet survey is on the next page to give you an idea of how to fill out your diet survey. Blank sheets are provided for your use.

On the back of one of the sheets please make a list of foods you would like to be able to have on your assigned diet. In other words, these foods you cannot do without (i.e., I have to have a glass of orange juice in the morning).

## SAMPLE

## 1 DAY OF DIET SURVEY

BREAKFAST

1 cup General Mills Cheerios  
 $\frac{1}{2}$  cup Betsy Bakers Skim Milk  
 1 slice Country Hearth Whole Wheat Bread - toasted  
 $\frac{1}{2}$  teaspoon soft Fleischman's Margarine  
 1 cup Shurfine 100% Orange Juice

SNACK (when applicable)

1 medium size apple

LUNCH

2 slices Country Hearth Whole Wheat Bread  
 2 tablespoons Skippy Peanut Butter  
 2 tablespoons Welch's Grape Jelly  
 1 medium orange  
 1 large peach  
 1 Oreo cookies

SNACK (when applicable)

no snack eaten

DINNER (List all foods eaten at dinner just as above)SNACK (when applicable)

DAY - MONDAY, OCTOBER 8, 1979

NAME \_\_\_\_\_

BREAKFAST

SNACK (when applicable)

LUNCH

SNACK (when applicable)

DINNER

SNACK (when applicable)

DAY - TUESDAY, OCTOBER 9, 1979

NAME \_\_\_\_\_

BREAKFAST

SNACK (when applicable)

LUNCH

SNACK (when applicable)

DINNER

SNACK (when applicable)

DAY - WEDNESDAY, OCTOBER 10, 1979

NAME \_\_\_\_\_

BREAKFAST

SNACK (when applicable)

LUNCH

SNACK (when applicable)

DINNER

SNACK (when applicable)

APPENDIX C  
SUBJECT CONTRACT

SUBJECT CONTRACT

Thursday, October 11, 1979

1. Eat 2 main meals during the day. The third main meal should be eaten after the run at 5 p.m. Small snacks may be eaten in between breakfast and lunch and up to two and one-half hours prior to the run at 5 p.m. No food, coffee, tea or any beverages other than water for two and one-half hours prior to testing.
2. Dress as you would during your normal running sessions. No new running shoes.
3. Be dressed and ready to run at 5 p.m. You will run a one-quarter mile warmup around the University of Nebraska at Omaha indoor track before beginning a 30 minute all-out run around the track. This will be the only physical activity for the day except for a 10 minute walk to class or work if necessary.
4. Hand in your 3 day diet survey that was done on Monday, Tuesday and Wednesday (October 8, 9 and 10).

Friday, October 12, 1979 or Saturday, October 13, 1979

1. The investigator will have given you the 5 day menu for Monday through Friday (October 15-19).

Monday, October 15, 1979 and Tuesday, October 16, 1979

1. Eat 3 main meals. Follow the assigned diet schedule for the day. No vitamin or mineral supplements may be taken.
2. No speedwork in any physical activity or sport (i.e., running,

swimming, tennis, bicycling, etc.).

3. DO NOT run or perform in any physical activity or sport longer than 30 minutes.
4. Please keep a log of any physical activity you do participate in on these days. Also, make a note in the log that you followed the assigned diet. The log for all five days will be handed in on Friday, October 19, at 5 p.m.

Wednesday, October 17, 1979

1. Follow the assigned diet schedule for Wednesday. No vitamin or mineral supplements may be taken.
2. Eat 2 main meals during the day before reporting for the timed run. The third meal will be eaten after the 5 p.m. run.
3. No food, coffee, tea or any beverages other than water for two and one-half hours prior to testing.
4. No physical activity lasting greater than 10 minutes (i.e., walking to work or class).
5. Be dressed and ready to run at 5 p.m. Wear the same clothing as that worn on Thursday, October 11, 1979.
6. Run a one-quarter mile warmup around the University of Nebraska at Omaha indoor track before beginning a 30 minute all-out run around the track.
7. Run a one-quarter mile cooldown after the 30 minute all-out run.
8. Keep your log on your physical activity and diet for the day.



Thursday, October 18, 1979 - "No training or physical activity day"

1. Follow the assigned diet schedule for Thursday. Eat 3 main meals.  
No vitamin or mineral supplements may be taken.
2. NO training or physical activity of any sort will be done on this day. Even such mild activities as walking or bicycling to and from class or work should not extend beyond 10 minutes of continuous exercise.
3. Keep a log of any walking or bicycling less than 10 minutes that you do if necessary. Also, make a note that you followed the diet menu.

Friday, October, 19, 1979

1. Follow the assigned diet schedule for Friday.
2. Eat 2 main meals during the day before reporting for the timed run.  
The third meal will be eaten after the 5 p.m. run.
3. No food, coffee, tea or any beverages other than water for two and one-half hours prior to testing. Also, no cigarette smoking two and one-half hours prior to testing. No vitamin or mineral supplements may be taken.
4. NO physical activity lasting greater than 10 minutes (i.e., walking to work or class).
5. Be dressed and ready to run at 5 p.m. Wear the same clothing as that worn on Thursday, October 11 and Wednesday, October 17.
6. Run a one-quarter mile warmup around the University of Nebraska at Omaha indoor track before the 30 minute all-out run.
7. Run a one-quarter of a mile cooldown after the 30 minute all-out run.

8. Write your log for the day listing any walking or bicycling less than 10 minutes that you do if necessary. Also, note you completed the assigned diet.

CONTRACT STATEMENT

I will complete the 3 day diet survey (October 8, 9 and 10) and follow the instructions for the pre-test given on Thursday, October 11, 1979. I have read and understand the list of expectations for each day of the week of October 15-19 (Monday-Friday) and will follow them exactly as given.

NAME \_\_\_\_\_

DATE \_\_\_\_\_

APPENDIX D  
INSTRUCTIONS FOR VOLUNTEERS

### INSTRUCTIONS FOR VOLUNTEERS

Please meet at 4:45 p.m. at the UNO field house indoor track on the following days:

1. Thursday, October 11
2. Wednesday, October 17
3. Friday, October 19

If for any reason you cannot make it please call that morning so I can find a replacement. Call Maureen Fennerty at 393-3326 or 554-2670 (leave a message with the secretary).

There will be ten males participating in a 30 minute all-out run around the UNO indoor track. Each runner will have a number pinned to his shirt. You will be assigned 2 runners to count laps for and record their  $\frac{1}{4}$  mile times (twice around the track). There will be 1 person with a stop watch who will yell out the time as each person completes a lap. You will record the time every 2 laps. Paper and pencil will be provided. The following is an example of how to record:

RUNNER # 1

NAME Mike Hall

LAP #

1

2 (time) 2:43

3

4 (time) 4:20

CONE #     

5

RUNNER # 2

NAME Mike Hall

LAP #

1

2 (time) 1:06

3

4 (time) 2:06

CONE #     

5

When 30 minutes are up the timer will blow a whistle signifying the end of the run. At this time record which orange cone is closest to each of your 2 runners. If a runner is halfway between cones record the cone he is running towards.